(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 May 2001 (17.05.2001)

PCT

(10) International Publication Number
WO 01/34973 A1

(51) International Patent Classification[7]: F03B 17/06, 13/10

(21) International Application Number: PCT/NL00/00828

(22) International Filing Date: 13 November 2000 (13.11.2000)

(25) Filing Language: Dutch

(26) Publication Language: English

(30) Priority Data:
1013559 11 November 1999 (11.11.1999) NL

(71) Applicant and
(72) Inventor: PAS, Peter, Alexander, Josephus [NL/NL]; Landweg 4, NL-7044 AN Lengel (NL).

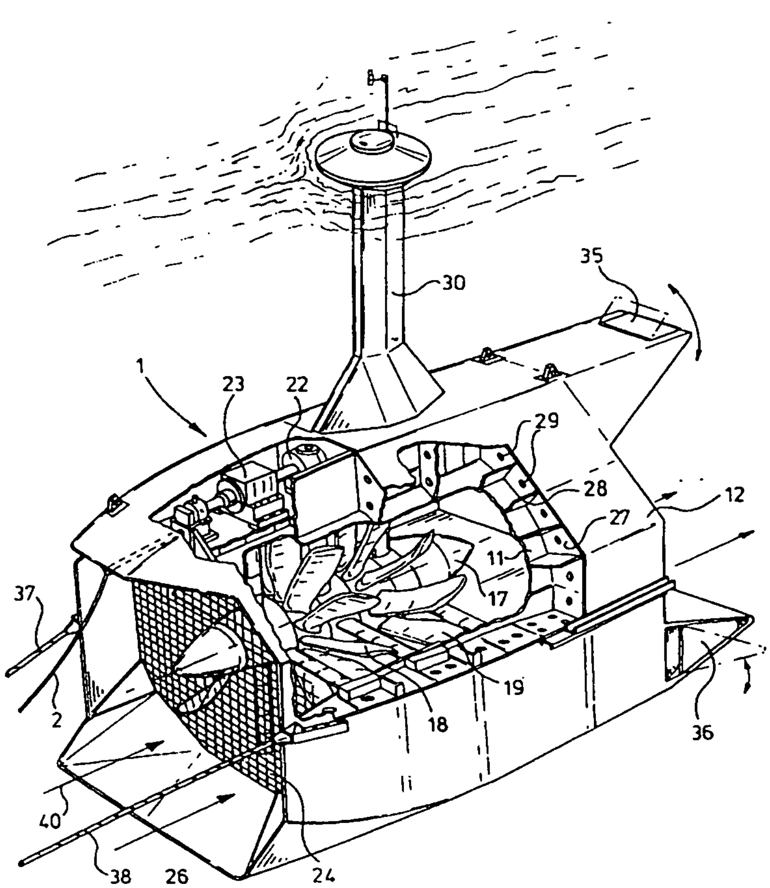
(74) Agent: JORRITSMA, Ruurd; Nederlandsch Octrooibureau, Scheveningseweg 82, P.O. Box 29720, NL-2502 LS The Hague (NL).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: SYSTEM FOR PRODUCING HYDROGEN MAKING USE OF A STREAM OF WATER



(57) Abstract: A system for producing hydrogen from water, making use of a stream of water such as a gulf stream or tidal stream, comprises a number of submerged modules (1), each having a turbine (17) that can be driven by the stream of water. The turbine is coupled to a generator (22) for generating electrical energy. Each module may have submerged decomposition means (23) for decomposing water into hydrogen and oxygen using the electrical energy generated. The modules (1) are provided with means to control the depth of the modules below water level, and furthermore with means for automatically orienting the front of the modules - viewed in the longitudinal direction of the turbines - to the direction of flow of the water or an angular position deviating therefrom.

WO 01/34973 A1

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SYSTEM FOR PRODUCING HYDROGEN MAKING USE OF A STREAM OF WATER

The invention relates to a system for producing hydrogen from water making use of a stream of water such as a gulf stream or tidal stream, comprising a number of submerged modules, each having a turbine that can be driven by the stream of water and that is coupled to a generator for generating electrical energy.

A system of this type is disclosed in US-A 4 850 190.

There are no environmental problems whatsoever associated with the production of hydrogen from water and the conversion of the hydrogen produced with oxygen. There are no harmful by-products, such as carbon dioxide, carbon monoxide, sulphur dioxide or nitrogen oxide. Streams of water such as gulf streams activated by solar energy and tidal streams activated by the phase of the moon are available free and the energy from these is not subject to exhaustion.

In the installation according to US-A 4 850 190 all modules are suspended from a cable system in series above one another in such a way that adverse weather conditions are not able to exert any adverse effect. The modules provided with a turbine and generator are suspended in the same direction, that is to say with their fronts facing towards the gulf stream.

This system has a number of significant disadvantages. The modules are difficult to access for maintenance and repair. The direction thereof cannot rapidly be adjusted to a change in the direction of flow of the water. The depth of each module cannot be so chosen that the turbine is driven by the fastest steam of water. The yield from the system will therefore be relatively low. In case of emergency to manoeuvre a module in a position transverse to the direction of flow is impossible. Such a case occurs for instance when the flow velocity of the water is too high.

The aim of the invention is to avoid these disadvantages and to this end the system

mentioned in the preamble is characterised in that the modules are provided with means to control the depth of the modules below water level, and with means for automatically orienting the front of the modules – viewed in the longitudinal direction of the turbines – to the direction of flow of the water or an angular position deviating therefrom.

Preferably, the means to enable the depth of the modules below water level to be adjusted to the depth where the flow of the water is the most advantageous consist of ballast tanks and at least one rudder blade that can be hinged about a horizontal axis and the modules are attached by their fronts, via at least two sloping or horizontal cables, to an anchor connected to the sea bed.

In order to may adjust the angular position with respect to the flow direction, a rudder blade hingeable about a vertical axis, can be used.

In order appreciably to increase the energy efficiency of the modules, the turbine of each module can be housed in a venturi-tube-shaped continuous flow channel having – viewed in the direction of flow – a channel which gradually narrows, an adjoining narrowed channel and an adjoining channel which gradually widens.

The decomposition means are preferably accommodated in the modules.

An access tower, which has a top section protruding above water level, is mounted on the top of each module.

To prevent the turbine being damaged by large fish and sea mammals, a grating is fitted on the front of the turbine of each module. Said grating can easily be cleaned to remove shell and algae growth if one or more brushes that can be moved on an arm are added to the grating.

The generator for each module could be arranged in line with the turbine. However, this is disadvantageous for the venturi effect described above. Therefore the generator of each module will be positioned a radial distance away from the turbine, the rotary movement of the turbines being transmitted via one or more gear transmissions and a rotary rod to the

shaft of the generator.

To save weight and prevent deformation, the turbine blades can be of hollow construction.

Preferably, each turbine has two sets of blades which can be made to rotate in opposing directions by the stream of water.

In order to be able to achieve the venturi effect and at the same time to provide sufficient space for ballast tanks and the like, the housing of the modules can be of double-walled construction, the areas between the double walls being divided into chambers by transverse partitions and longitudinal partitions. As a consequence of the use of the ballast tanks, the modules can also be made floatable.

At least some of the chambers can be in communication with one another via openings in the partitions. The system has a central storage tower anchored on the seabed and a jetty and means for transferring hydrogen stored in tanks to the shore or a tanker.

The central storage tower is in communication, via a hydrogen transport line, with a hydrogen transport line that extends from each module, the point at which the two lines are joined being located on anchors to which the modules are connected via cables.

The invention also relates to a module that is suitable for the above-mentioned system.

The invention will now be explained in more detail with reference to the figures, in which an illustrative embodiment is shown.

Figure 1 shows a partially exposed, perspective view of the system.

Figure 2 shows a partially exposed, perspective view of a module employed.

Figure 3 shows a longitudinal section of the module.

The system shown for the production of hydrogen comprises a large number of modules 1

which are connected via lines 2, 3 to a central storage tower 4. The storage tower has tanks 5 to accommodate the hydrogen produced under relatively high pressure, for example up to 30 bar, as well as areas 6 that can serve as storage and office areas. A storage tower is anchored on the seabed.

A platform 7 with light beacon 8 is mounted on top of the storage tower. A jetty 9 where a tanker 10 or other ship can moor adjoins the platform 7.

Each module 1 has a double-walled housing with inside walls 11 and outside walls 12. The housing encircles a flow channel 13 that is in the form of a venturi, that is to say – viewed from front to back – a section 14 that becomes narrower from the outside towards the inside and merges into a narrow section 15, which in turn merges into a section 16 that widens from the inside towards the outside. A turbine 17 is mounted in the flow channel 13, which turbine 17 has two sets 18 and 19 of blades which are driven by the stream of water through the channel 13, as a result of which their shafts are made to rotate. To save weight, blades can be of hollow construction. The shafts of the sets of blades are connected via a gear transmission 20 to a rotary rod 21. The blades of the sets 18, 19 are so oriented that their shafts are driven by the stream of water in the opposing direction. The gear transmission 20 transmits the rotary movement of the shafts of both sets of blades to the rotary rod 21 in such a way that the latter rotates in one direction. A generator 22, which generates electrical energy, is made to rotate via a transmission at the other end of the rotary rod 21. The electrical energy generated is used in a decomposition apparatus 23, which has an anode and a cathode, to decompose water into hydrogen and oxygen. A high hydrogen pressure, for example up to 30 bar, can be achieved if the reaction $2H_2O \rightarrow 2H_2 + O_2$ is carried out in water inside the decomposition apparatus to which KOH has been added. The decomposition apparatus 22 operates batchwise.

The hydrogen produced is stored under the pressure produced in pressure vessels, which are not shown and which are located in one or more chambers of the double wall of the housing 11, 12. A grating 24 that prevents large sea mammals, such as sharks or whales, from being able to damage the turbine is fitted on the front of the housing. A brush 26 mounted on a rotary arm enables shells and algae to be removed from the grating.

The double-walled housing is divided into chambers by transverse partitions 27 and longitudinal partitions 28. Some chambers serve as ballast tanks, by means of which the buoyancy of the module can be controlled. There are one or more pumps, which are not shown, on board to supply and discharge the ballast water. Other chambers are in communication with one another via holes 29.

An access tower 30 with a wide entry and exit section 31 for maintenance personnel is mounted on each module 1. A stairway 32 extends through the length of the tower, as does an air pipe 33.

A rudder blade 35 that can be turned about a horizontal axis and a rudder blade 36 that can be turned about a vertical axis are mounted at the rear of each module 1. At the front, each module is connected by two sloping or horizontal cables 37, 38 to the top of an anchor post 39 anchored on the seabed.

The hydrogen line 2 from each module runs to the top of the anchor post 39 concerned, where it is connected to a line 3 which leads to the central storage tower 4.

The vertical positioning of each module at the most favourable water depth is effected by means of said ballast tanks and the rudder blade 35 that can be turned about a horizontal axis. Positioning of each module 1 such that the front thereof is oriented such that it directly faces the direction of flow (indicated by 40 in Fig. 2) takes place essentially automatically in that the two cables 37, 38 are pivotably connected to the top section of the anchor post 39. The water flowing through the venturi-shaped flow channel brings the module into the most advantageous direction with respect to the gulf stream or tidal stream. This means that, in the case of a tidal stream, when the tides change the modules turn through approximately 180° with respect to the anchor post 39 to which they are connected by the two cables 37, 38.

By removing water from the ballast chamber, a module can be towed as a vessel (see Figure 1). The module can be placed on the bottom by filling the ballast chambers, eventually supported by the rudder blade 35.

The oxygen produced can be released into the air, either from each module or from the central storage tower. Another possibility is to store the oxygen in vessels and to market this.

The rudder blade 36 that can be remote controlled and can be turned about a vertical axis serves to enable the position of the module with respect to the stream of water to be changed and to enable corrections to be made to the angular position of the module in the horizontal plane. If for instance the flow velocity of the water is rising to such a high value that there is a risk for damaging the sets of blades 18, 19 or the bearing thereof, the modules are manoeuvred in a direction transverse to the waterflow so that the sets of blades will not be driven. It can also be that the sets of blades 18, 19 are adjustable and that – in case of a too high water flow – the sets of blades are brought in such an angular position that they are not driven. The adjustment of the blade angular takes place by remote control.

Claims

1. System for producing hydrogen from water making use of a stream of water such as a gulf stream or tidal stream, comprising a number of submerged modules, each having a turbine that can be driven by the stream of water and that is coupled to a generator for generating electrical energy, characterised in that the modules (1) are provided with means to control the depth of the modules below water level, and with means for automatically orienting the front of the modules – viewed in the longitudinal direction of the turbines – to the direction of flow of the water or an angular position deviating therefrom.

2. System according to Claim 1, characterised in that the means to enable the depth of the modules below water level to be adjusted to the depth where the flow of the water is the most advantageous consist of ballast tanks and at least one rudder blade (35) that can be hinged about a horizontal axis and in that the modules are attached by their fronts, via at least two sloping or horizontal cables (37, 38), to an anchor (39) connected to the sea bed.

3. System according to Claim 1 or 2, characterised in that the module also has a rudder blade (26) hingeable about a vertical axis.

4. System according to one of the preceding claims, characterised in that the decomposition means (23) for decomposing water into hydrogen and oxygen using the electrical energy generated, are accommodated in the modules.

5. System according to one of the preceding claims, characterised in that the turbine (17) of each module (1) is housed in a venturi-tube-shaped continuous flow channel (13) having – viewed in the direction of flow – a channel (14) which gradually narrows, an adjoining narrowed channel (15) and an adjoining channel (16) which gradually widens.

6. System according to one of the preceding claims, characterised in that an access tower (30), which has a top section (31) protruding above water level, is mounted on the top of each module (1).

7. System according to one of the preceding claims, characterised in that a grating (24) is fitted on the front of the turbine of each module (1).

8. System according to Claim 7, characterised in that one or more brushes (26) that can be moved on an arm are added to said grating (24).

9. System according to one of the preceding claims, characterised in that the generator (22) of each module (1) is positioned a radial distance away from the turbine (17) and the rotary movement of the turbines is transmitted via one or more gear transmissions (20) and a rotary rod (21) to the shaft of the generator (22).

10. System according to one of the preceding claims, characterised in that the turbine blades (18) are of hollow construction.

11. System according to one of the preceding claims, characterised in that each turbine has two sets (18, 19) of blades which can be made to rotate in opposing directions by the stream of water.

12. System according to one of the preceding claims, characterised in that the housing of the modules is of double-walled (11, 12) construction and the areas between the double walls are divided into chambers by transverse partitions (27) and longitudinal partitions (28).

13. System according to Claim 12, characterised in that at least some of the chambers are in communication with one another via openings (29) in the partitions.

14. System according to one of the preceding claims, characterised in that the system has a central storage tower (4) anchored on the sea bed and a jetty (19) and means for transferring hydrogen stored in tanks to the shore or a tanker.

15. System according to Claim 14, characterised in that the central storage tower is in communication, via hydrogen transport lines (3), with a hydrogen transport line (2) that extends from each module, the point at which the lines (2) and (3) are joined being located

on anchors (39) to which the modules (1) are connected via cables (37, 38).

16. Module suitable for the system according to one of the preceding claims.

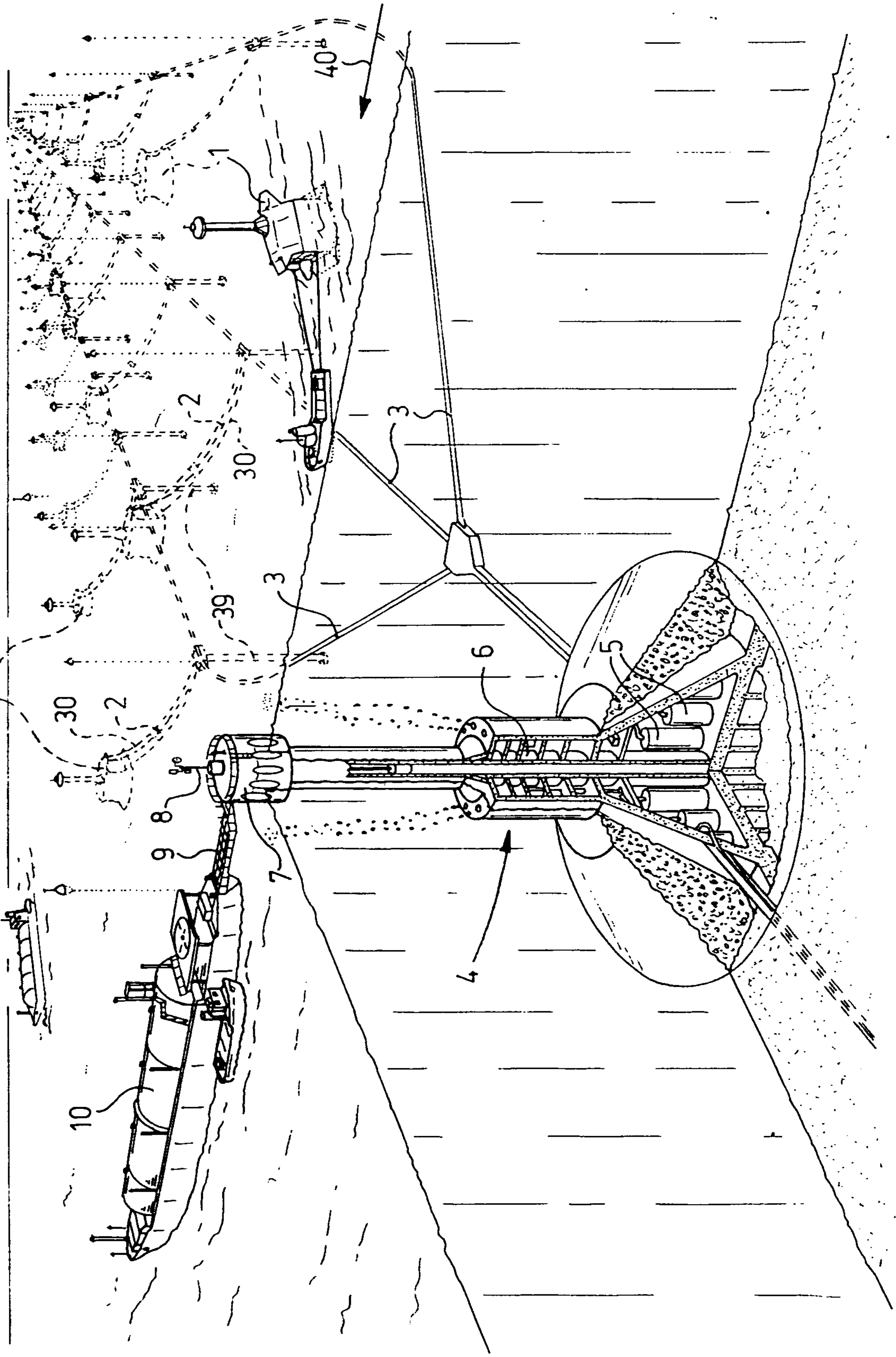


Fig-1

Fig-2

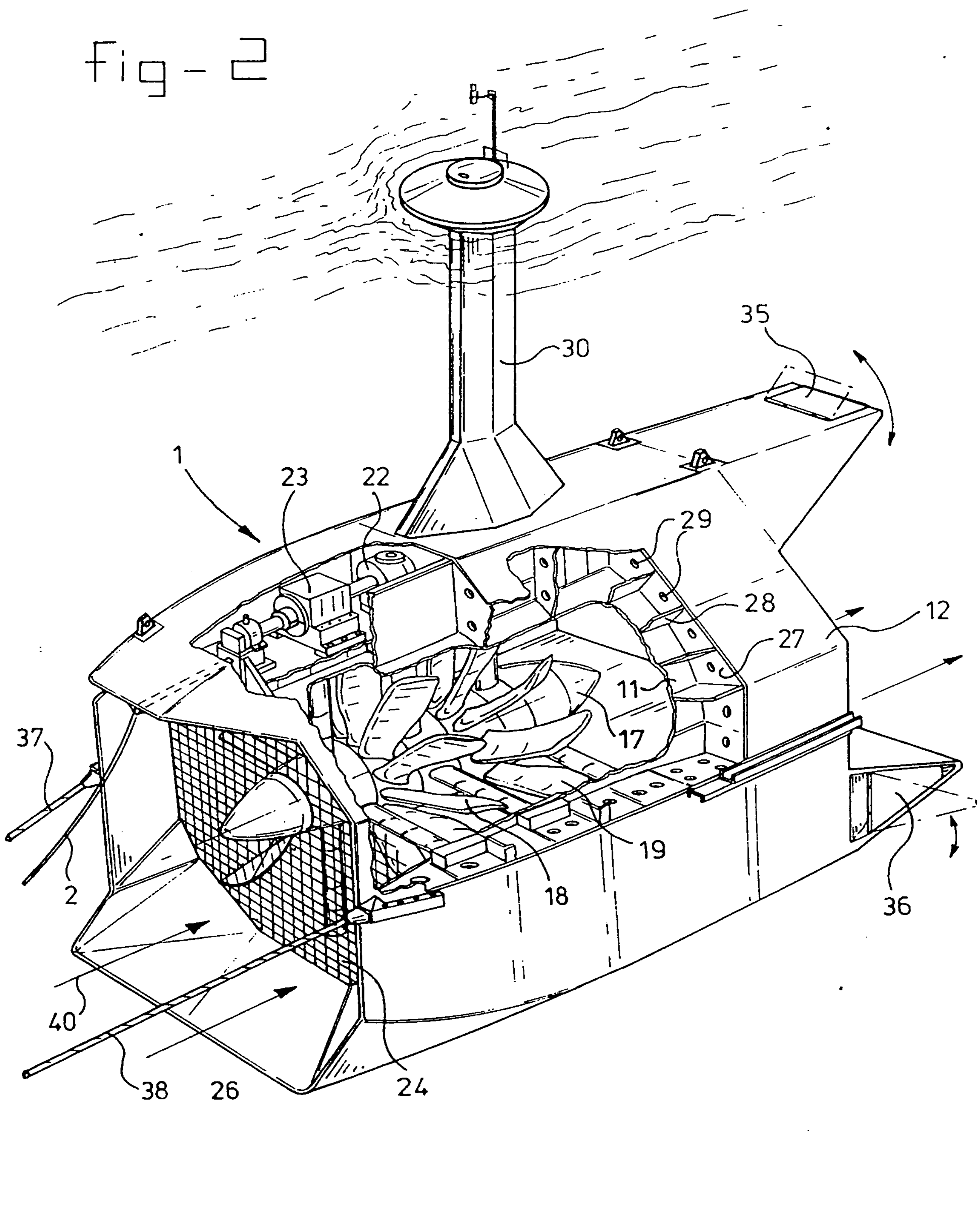
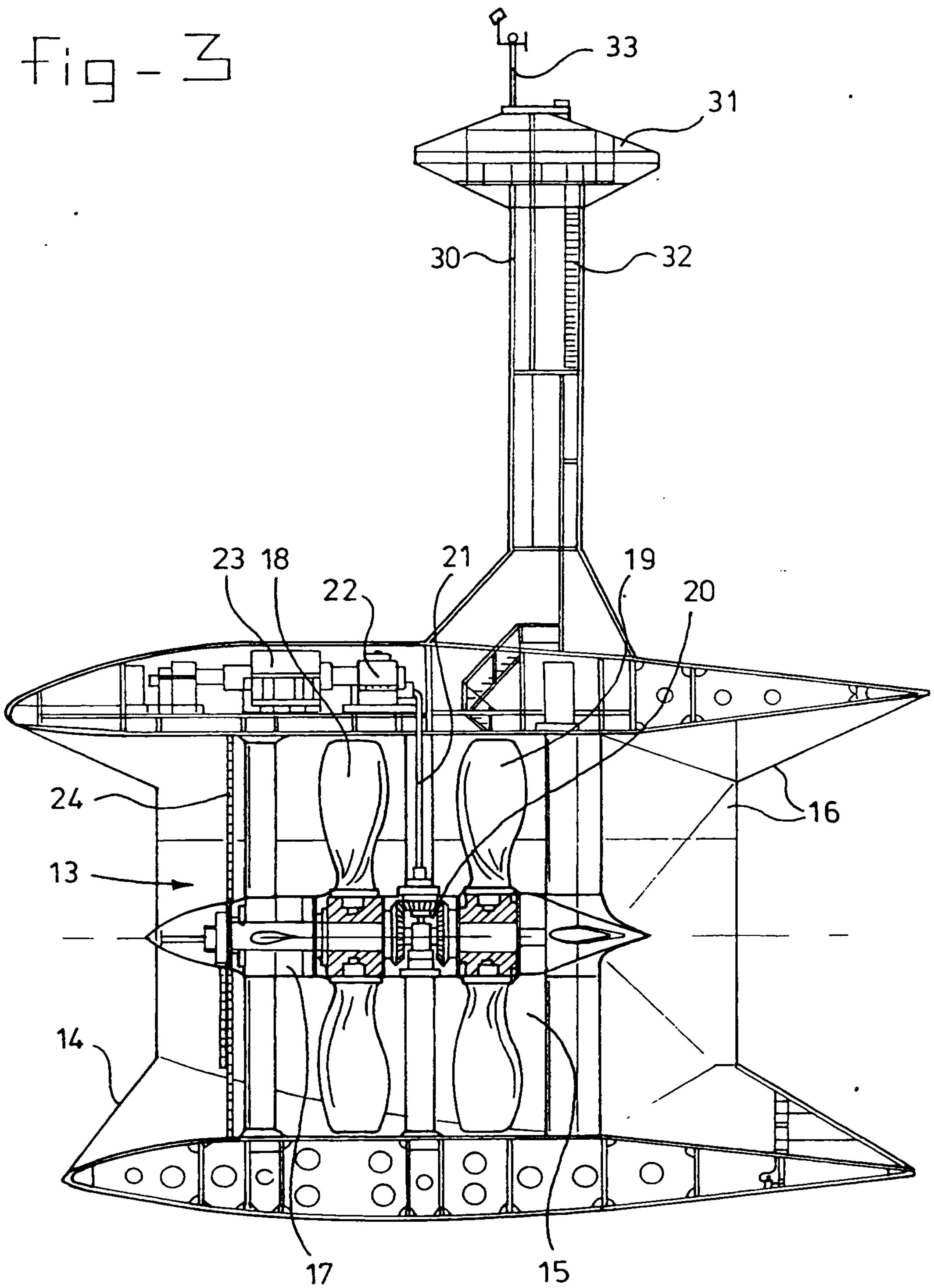


Fig-3



International Application No
PCT/NL 00/00828

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F03B17/06 F03B13/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 81 00595 A (BBC BROWN BOVERI & CIE ;KELM H (DE)) 5 March 1981 (1981-03-05)	1-4,6, 10,15
A	the whole document	11-13
Y	DE 41 25 691 A (DOERPINGHAUS ERNST H) 4 February 1993 (1993-02-04) abstract; figure 1	1-4,6, 10,15
Y	US 4 868 408 A (HESH FRANK) 19 September 1989 (1989-09-19) abstract; figure 1	1-4,6, 10,15
Y	US 4 850 190 A (PITTS THOMAS H) 25 July 1989 (1989-07-25) cited in the application the whole document	1-4,6, 10,15

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 February 2001	28/02/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Iverus, D

1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 00/00828

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 440 176 A (HAINING MICHAEL L) 8 August 1995 (1995-08-08) figure 2	1,5
A	US 5 512 787 A (DEDERICK ROBERT) 30 April 1996 (1996-04-30)	

1

INTERNATIONAL SEARCH REPORT

Int. ational Application No
PCT/NL 00/00828

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 8100595	A	05-03-1981	DE	2933907	A	12-03-1981
			EP	0034605	A	02-09-1981
DE 4125691	A	04-02-1993	NONE			
US 4868408	A	19-09-1989	NONE			
US 4850190	A	25-07-1989	NONE			
US 5440176	A	08-08-1995	AU	687629	B	26-02-1998
			AU	3423895	A	02-05-1996
			CA	2160756	A	19-04-1996
			EP	0708241	A	24-04-1996
			JP	8210237	A	20-08-1996
			NO	954156	A	19-04-1996
US 5512787	A	30-04-1996	AU	4004395	A	15-05-1996
			WO	9612871	A	02-05-1996